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(54) **LIGHT EMITTING DIODE PACKAGE**

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H01L 33/62 (2010.01)

H01L 33/48 (2010.01)

(52) **U.S. Cl.**

CPC ***H01L 33/62*** (2013.01); *H01L 33/486* (2013.01); *H01L 2924/0002* (2013.01); *H01L 2224/13* (2013.01); *H01L 2224/48247* (2013.01); *H01L 2224/73265* (2013.01)

(58) **Field of Classification Search**

CPC H01L 33/62

USPC 257/99

See application file for complete search history.

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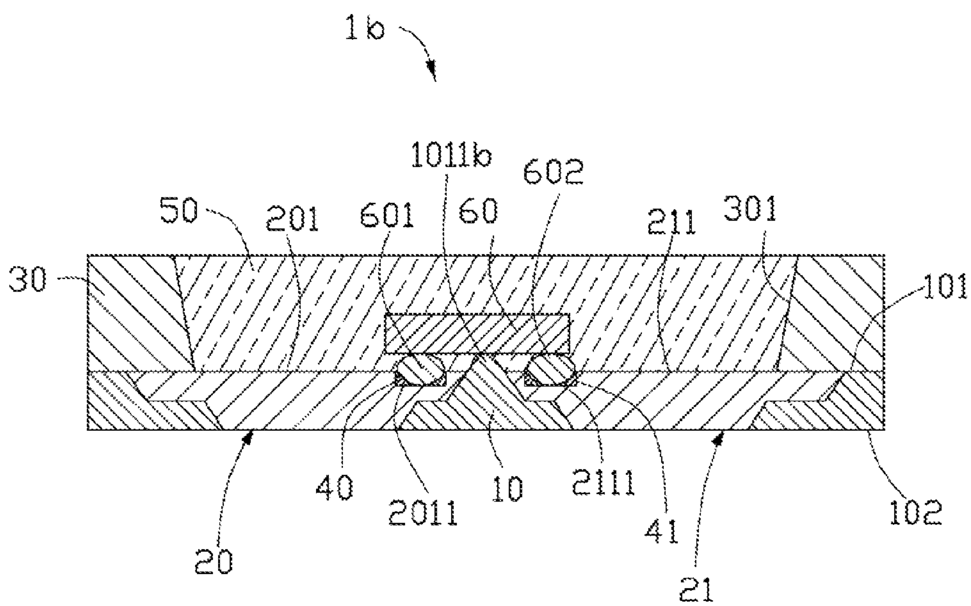
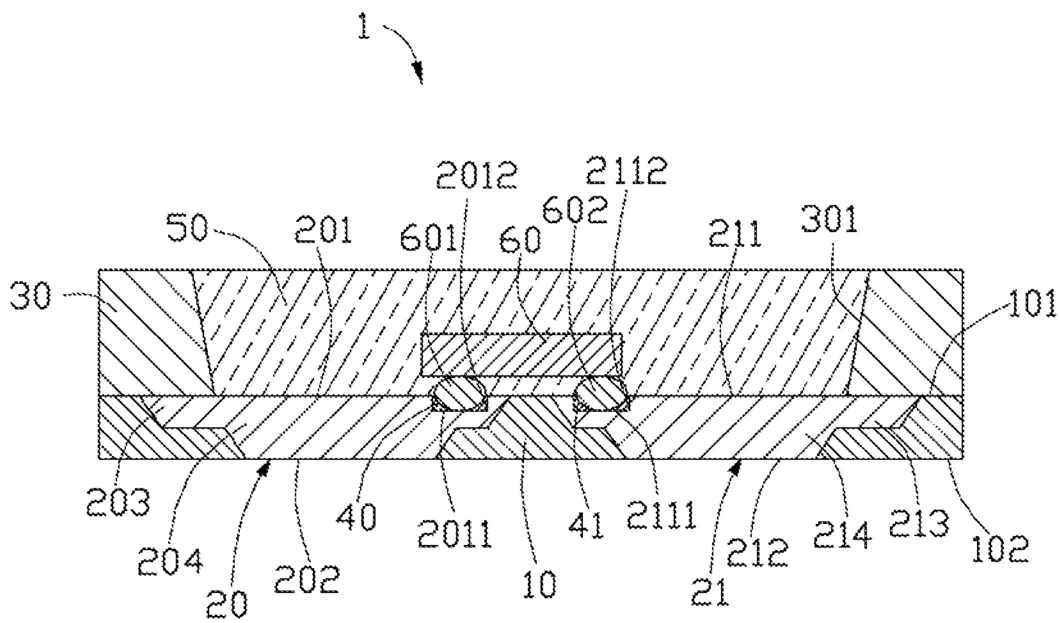
(57) **ABSTRACT**

A light emitting diode (LED) package includes a substrate, a first electrode and a second electrode embedded in the substrate and spaced from each other, an LED die mounted on a top surface of the substrate and electrically connected to the first and the second electrodes. Both the first and the second electrodes include a top face and a bottom face, with the top face and the bottom face of each of the first and the second electrodes being exposed at the top surface and a bottom surface of the substrate, respectively. The top face of the first electrode defines a first groove corresponding to a positive bonding pad (p-pad) of the LED die. The p-pad is partially inserted into the first groove. An oxidation-resistant metal coating layer is filled between an insertion portion of the p-pad and an inner surface of the first groove.

17 Claims, 4 Drawing Sheets

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2012
2112
50
201
601
60
602
211
301
30
101
203
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202
40
2011
10
41
2111
21
212
214
213
102

FIG. 1

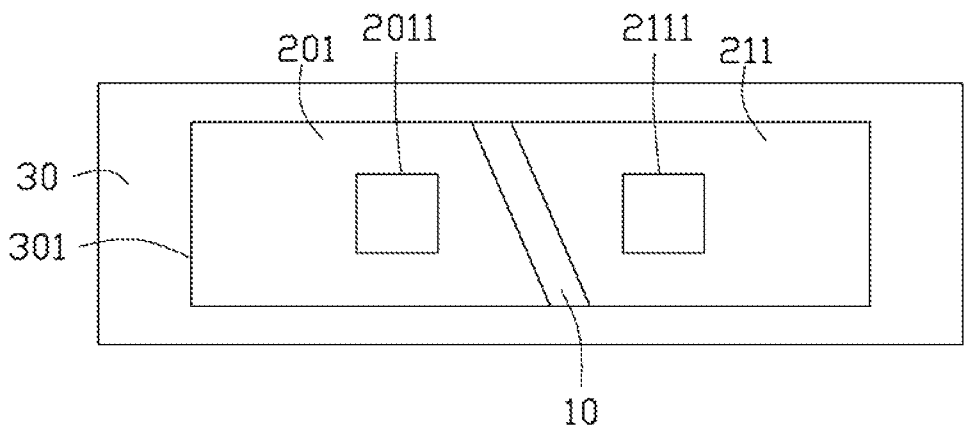

FIG. 2

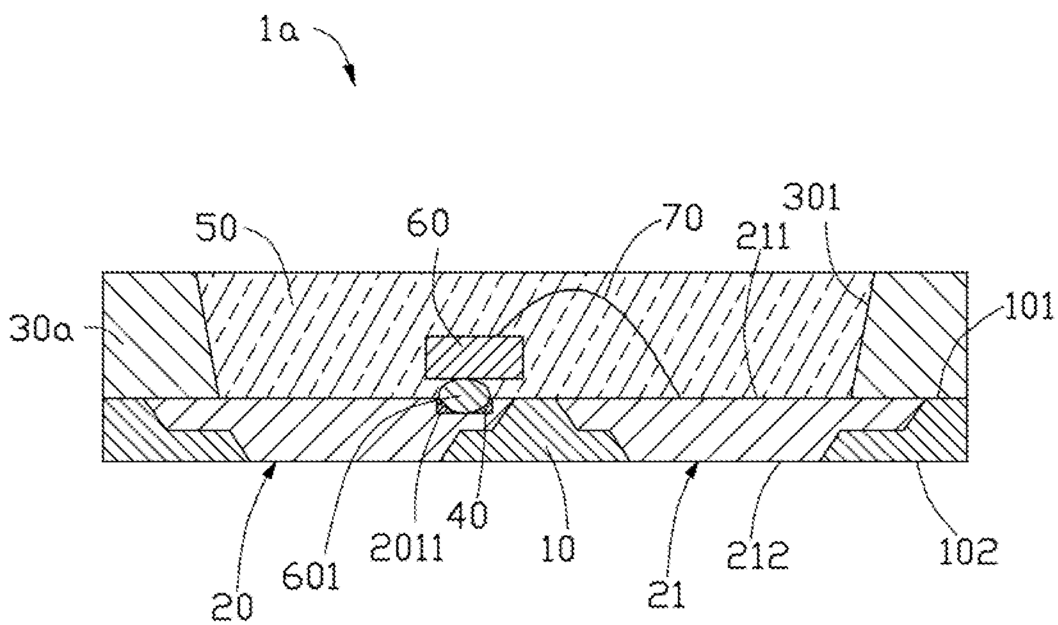

FIG. 3

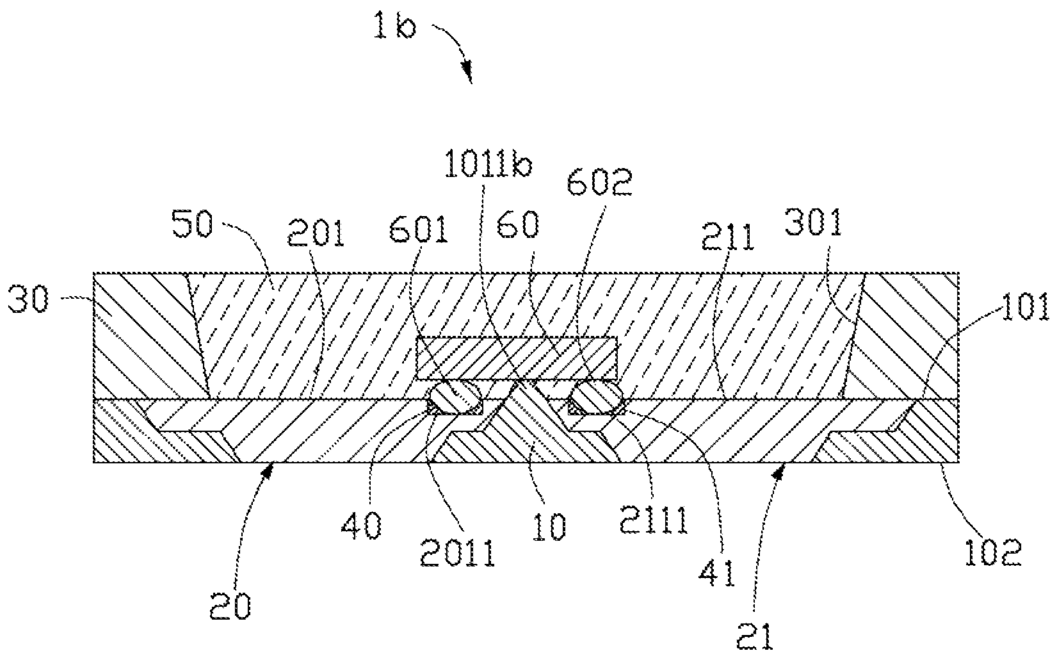
1b
1011b
602
50
201
601
60
211
301
30
101
40
2011
10
2111
41
102
20
21

FIG. 4

LIGHT EMITTING DIODE PACKAGE

TECHNICAL FIELD

The present disclosure relates generally to a light emitting diode (LED) package, wherein the LED package has an improved oxidation resistance and a high heat dissipation efficiency.

DESCRIPTION OF RELATED ART

LEDs are solid state light emitting devices formed of semiconductors, which are more stable and reliable than other conventional light sources. Thus, LEDs are being widely used in various fields such as numeral/character displaying elements, signal lights, light sources for lighting and display devices.

A traditional LED package usually includes a substrate, a first electrode formed on the substrate, a second electrode formed on the substrate and spaced from the first electrode, and an LED die mounted on a top surface of the substrate. The LED die is electrically connected to the first and the second electrodes by a flip-chip technology, with a positive bonding pad (p-pad) and a negative bonding pad (n-pad) thereof directly contacting with the first and the second electrodes respectively. In order to prolong a life-span of the LED package, it is common to form an encapsulation layer on the substrate to encapsulate the LED die, whereby the LED die of the LED package is isolated from humid ambient air.

However, the humid air is easily permeable into the inside of the LED package from a substrate-encapsulation layer interface due to a weak bonding force existing between the encapsulation layer and the substrate, especially when the encapsulation layer is made of a material such as silicon resin or epoxy resin, whereby an area of a top surface of the first/second electrode corresponding to p-pad/n-pad is prone to oxidation by the humid air permeating into the inside of the LED package. Therefore, such an LED package is difficult to satisfy the requirements of oxidation resistance. Furthermore, the heat generated by the LED die is difficult to be dissipated, which greatly accelerates the deterioration and degradation of the LED package.

What is needed therefore is a light emitting diode (LED) package which can overcome the above mentioned limitations.

BRIEF DESCRIPTION OF THE DRAWINGS

Many aspects of the present embodiments can be better understood with reference to the following drawings. The components in the drawings are not necessarily drawn to scale, the emphasis instead being placed upon clearly illustrating the principles of the present embodiments. Moreover, in the drawings, like reference numerals designate corresponding parts throughout the views.

FIG. **1** is a schematic, cross-sectional view of a light emitting diode (LED) package in accordance with a first embodiment of the present disclosure.

FIG. **2** is a top plan view of the LED package of FIG. **1**, with an LED die and an encapsulation layer thereof being omitted for clarity.

FIG. **3** is a schematic, cross-sectional view of a light emitting diode (LED) package in accordance with a second embodiment of the present disclosure.

FIG. **4** is a schematic, cross-sectional view of a light emitting diode (LED) package in accordance with a third embodiment of the present disclosure.

DETAILED DESCRIPTION

Referring to FIGS. **1** and **2**, a light emitting diode (LED) package **1** in accordance with a first embodiment of the present disclosure includes a substrate **10**, a first electrode **20** embedded in the substrate **10**, a second electrode **21** embedded in the substrate **10** and spaced from the first electrode **20**, an LED die **60** mounted on the substrate **10**, a reflective cup **30** formed on the substrate **10**, and an encapsulation layer **50** covering on the substrate **10** and encapsulating the LED die **60**. The LED die **60** is reversely disposed, with a positive bonding pad (p-pad) **601** and a negative bonding pad (n-pad) **602** thereof being electrically connected to the first and the second electrodes **20**, **21** respectively.

The substrate **10** includes a top surface **101** and a bottom surface **102**. In the present embodiment, the substrate **10** is rectangular, and both the top and the bottom surfaces **101**, **102** of the substrate **10** are horizontal surfaces which are in parallel with each other. The substrate **10** is a highly heat conductive and electricity insulated substrate which is made of a material such as Si resin or ceramic, whereby the substrate **10** is electrically insulated from the first and the second electrodes **20**, **21**.

The first and the second electrodes **20**, **21** penetrate downward through the substrate **10** from the top surface **101** to the bottom surface **102** of the substrate **10**, respectively. The first electrode **20** includes a top face **201** and a bottom face **202** opposite to the top face **201** thereof. The second electrode **21** includes a top face **211** and a bottom face **212** opposite to the top face **211**. Both the top faces **201**, **211** of the first and second electrodes **20**, **21** are exposed at the top surface **101** of the substrate **10**. Both the bottom faces **202**, **212** of the first and second electrodes **20**, **21** are exposed at the bottom surface **102** of the substrate **10**.

In the present embodiment, both the top faces **201**, **211** of the first and second electrodes **20**, **21** are coplanar with the top surface **101** of the substrate **10**, and both the bottom faces **202**, **212** of the first and second electrodes **20**, **21** are coplanar with the bottom surface **102** of the substrate **10**. Alternatively, both the top faces **201**, **211** of the first and the second electrodes **20**, **21** protrude upwardly from the top surface **101** of the substrate **10**, and both the bottom faces **202**, **212** of the first and the second electrodes **20**, **21** protrude downwardly from the bottom surface **102** of the substrate **10**.

The first and the second electrodes **20**, **21** have a T-shaped transverse cross-section along a thickness direction thereof respectively, whereby an effective contacting area between the first or the second electrode **20**, **21** and the substrate **10** is greatly increased. More in details, the first electrode **20** includes a main body **203** and a branch portion **204** integrally extending downwardly from a central region of a bottom face of the main body **203**. The main body **203** is trapezoidal in cross section. The branch portion **204** is trapezoidal in cross section. The branch portion **204** has a size smaller than that of the main body **203**, and two steps are formed at two lateral joints of the main body **203** and the branch portion **204**. Similarly, the second electrode **21** includes a main body **213** and a branch portion **214** integrally extending downwardly from a central region of a bottom face of the main body **213**. The main body **213** is trapezoidal in cross section. The branch portion **214** is trapezoidal in cross section. The branch portion **214** has a size smaller than that of the main body **213**, and two steps are formed at two lateral joints of the main body **213** and the branch portion **214**.

The reflective cup **30** is arranged on the top surface **101** of the substrate **10**. The reflective cup **30** defines a receiving cavity **301** therein. The LED die **60** is received in the receiving cavity **301** and surrounded by the reflective cup **30**. A lateral outer periphery of the reflective cup **30** is aligned with a lateral periphery of the substrate **10**. In the present embodiment, the reflective cup **30** is integrally formed with the substrate **10** as a monolithic piece by injection molding. Alternatively, the reflective cup **30** and the substrate **10** are separately modeled, and then integrated into one monolithic piece. It is preferred that the reflective cup **30** is made of a material such as silicon resin or epoxy resin.

The top face **201** of the first electrode **20** and the top face **211** of the second electrode **21** each are trapezoidal. A majority of the top face **201** is exposed at a bottom of the receiving cavity **301** of the reflective cup **30**, with a left-side portion of the top face **201** of the first electrode **20** being covered by the reflective cup **30**. Similarly, a majority of the top face **211** is exposed at a bottom of the receiving cavity **301** of the reflective cup **30**, with a right-side portion of the top face **211** of the second electrode **21** being covered by the reflective cup **30**. That is to say, a short side of the top face **201** of the first electrode **20** away from the second electrode **21** and a short side of the top face **211** of the second electrode **21** away from the first electrode **20** are covered by the reflective cup **30**, respectively.

The encapsulation layer **50** is formed in the receiving cavity **301** of the reflective cup **30** and encapsulates the LED die **60** therein. The encapsulation layer **50** completely fills up the receiving cavity **301**, i.e., a top of the reflective cup **30** being coplanar with a top surface (not labeled) of the encapsulation layer **50**. It is preferred that the encapsulation layer **50** contains phosphor particles distributed therein to scatter and convert a wavelength of light rays emitted from the LED die **60**.

The top face **201** of the first electrode **20** defines a first groove **2011** corresponding to the p-pad **601** of the LED die **60**, and the top face **211** of the second electrode **21** defines a second groove **2111** corresponding to the n-pad **602** of the LED die **60**. The first groove **2011** is located adjacent to a junction of the first electrode **20** and the substrate **10**. The first groove **2011** is adjacent to the second electrode **21** but spaced from the substrate **10**. The second groove **2111** is located adjacent to a junction of the second electrode **21** and the substrate **10**. The second groove **2111** is adjacent to the first electrode **20** but spaced from the substrate **10**. In other words, each of the first and the second grooves **2011**, **2111** is spaced from the substrate **10** by a short distance.

The p-pad **601** of the LED die **60** is partially inserted into the first groove **2011**. The n-pad **602** of the LED die **60** is partially inserted into the second groove **2111**. More in details, a depth of the first groove **2011** is smaller than a thickness of the p-pad **601**. A depth of the second groove **2111** is smaller than a thickness of the n-pad **602**. A top portion of the p-pad **601** protrudes beyond the first groove **2011**, and a top portion of the n-pad **602** protrudes beyond the second groove **2111**. Alternatively, a depth of the first groove **2011** is equal to a thickness of the p-pad **601**, and a depth of the second groove **2111** is equal to a thickness of the n-pad **602**. That it to say, the p-pad **601** and the n-pad **602** are completely received in the first and second grooves **2011**, **2111**, respectively.

In the present embodiment, the p-pad **601** and the n-pad **602** are spherical, while the first and the second grooves **2011**, **2111** are cylindrical. The first groove **2011** has an inner surface **2012**, and the second groove **2111** has an inner surface **2112**. Both the inner surfaces **2012**, **2112** of the first and the second grooves **2011**, **2111** include a square bottom face and a quadrangular prism-shaped sidewall extending upwardly from an outer periphery of the bottom face. The insertion portion of the p-pad **601** directly contacts with the bottom face and a top end of the sidewall of the first groove **2011**. The insertion portion of the n-pad **602** directly contacts with the bottom face and a top end of the sidewall of the second groove **2111**.

A first oxidation-resistant metal coating layer **40** made of Au is filled in the gap defined between the insertion portion of the p-pad **601** and the inner surface **2012** of the first groove **2011**. A second oxidation-resistant metal coating layer **41** made of Au is filled in the gap defined between the insertion portion of the n-pad **602** and the inner surface **2112** of the second groove **2111**.

It is to be understood that a shape of the first and the second grooves **2011**, **2111** could be changed according with a shape of the p-pad **601** and the n-pad **602**, respectively. For instance, the first and the second grooves **2011**, **2111** are semi-spherical, and accordingly, the p-pad **601** is smoothly received in the first groove **2011**, with the first oxidation-resistant metal coating layer **40** being sandwiched between the insertion portion of the p-pad **601** and the inner surface **2012** of the first groove **2011**. That is to say, an outer peripheral surface of the insertion portion of the p-pad **601** is separated from the inner surface **2012** of the first groove **2011** by the first oxidation-resistant metal coating layer **40**. Similarly, the n-pad **602** is smoothly received in the second groove **2111**, with the second oxidation-resistant metal coating layer **41** being sandwiched between the insertion portion of the n-pad **602** and the inner surface **2112** of the second groove **2111**, which means that an outer peripheral surface of the insertion portion of the n-pad **602** is separated from the inner surface **2112** of the second groove **2111** by the second oxidation-resistant metal coating layer **41**.

Referring to FIG. **3**, a light emitting diode (LED) package **1***a* in accordance with a second embodiment is illustrated. Different from that the p-pad **601** and the n-pad **602** are located at a bottom side of the LED die **60** of the LED package **1** as shown in FIG. **1**, the p-pad **601** and the n-pad **602** of the LED die **60** are located at two opposite sides of the LED die **60** of the LED package **1***a*. More in details, the n-pad (not shown) located at a top side of the LED die **60** is directly electrically connected to the top face **211** of the second electrode **21** via wire **70**.

Referring to FIG. **4**, a light emitting diode (LED) package **1***b* in accordance with a third embodiment is illustrated. Different from the LED package **1** as shown in FIG. **1**, a portion **1011***b* of the top surface **101** of the substrate **10** located between the first and the second electrodes **20**, **21** protrudes from the top faces **201**, **211** of the first and second electrodes **20**, **21** by a predetermined distance so as to reach a bottom side of the LED die **60**. That is to say, the LED die **60** is held at a predetermined height above the first and the second electrodes **20**, **21** by the protrusion portion **1011***b* of the top surface **101** of the substrate **10**.

A height of the protrusion portion **1011***b* of the top surface **101** of the substrate **10** is not less than a difference between a thickness of the p-pad **601** and a depth of the first groove **2011** but smaller than a thickness of the p-pad **601**. Similarly, the height of the protrusion portion **1011***b* of the top surface **101** is not less than a difference between a thickness of the n-pad **602** and a depth of the second groove **2111** but smaller than a thickness of the n-pad **602**. That it to say, a gap defined between the insertion portion of the p-pad **601** and the inner surface **2012** of the first groove **2011**, together with a gap defined between the insertion portion of the n-pad **602** and the inner surface **2112** of the second groove **2111**, could be changed according to the specific height of the protrusion portion **1011***b* of the top surface **101** of the substrate **10**. In the present embodiment, the p-pad **601** and the first oxidation-resistant metal coating layer **40** are joined together by eutectic boding technology. Similarly, the n-pad **602** and the second oxidation-resistant metal coating layer **41** are joined together by eutectic boding technology.

In the present disclosure, the first and the second electrodes **20**, **21** have a T-shaped transverse cross-section along a thickness direction thereof respectively, and each of the first and the second grooves **2011**, **2111** is spaced from the substrate **10** by a short distance, so a path of the humid air along the junction of the first electrode **20** or the second electrode **21** and the substrate **10** is greatly extended, thereby effectively delaying deterioration rate of the LED package **1** (**1***a*, **1***b*). What's more, the first oxidation-resistant metal coating layer **40** is filled between the insertion portion of the p-pad **601** and the inner surface **2012** of the first groove **2011**, and the second oxidation-resistant metal coating layer **41** is filled between the insertion portion of the n-pad **602** and the inner surface **2112** of the second groove **2111**, whereby an area of the top face **201** of the first electrode **20** corresponding to the p-pad **601** is covered by the first oxidation-resistant metal coating layer **40** to prevent the first electrode **20** from air oxidation, and an area of the top face **211** of the second electrode **21** corresponding to the n-pad **602** is covered by the second oxidation-resistant metal coating layer **41** to prevent the second electrode **21** from air oxidation, whereby an oxidation resistance of the LED package **1** (**1***a*, **1***b*) is greatly improved. Furthermore, the bottom face **202** of the first electrode **20** and the bottom face **212** of the second electrode **21** are exposed at the bottom surface **102** of the substrate **10**, through which the heat generated by the LED die **60** is effectively dissipated to the ambient environment. In addition, the p-pad **601** and the n-pad **602** are inserted into the first and the second grooves **2011**, **2111**, which effectively increasing a contacting area between the p-pad **601** or the n-pad **602** and the first or the second electrode **20**, **21**, thus the LED package **1** (**1***a*, **1***b*) having an improved electrical conductivity is obtained.

It is believed that the present embodiments and their advantages will be understood from the foregoing description, and it will be apparent that various changes may be made thereto without departing from the spirit and scope of the disclosure or sacrificing all of its material advantages, the examples hereinbefore described merely being preferred or exemplary embodiments of the disclosure.

What is claimed is:

1. A light emitting diode (LED) package comprising:

a substrate comprising a top surface and a bottom surface;

a first electrode and a second electrode spaced from the first electrode, both the first and the second electrodes being embedded in the substrate, both the first and the second electrodes comprising a top face and a bottom face, the top faces of the first and the second electrodes being exposed at the top surface of the substrate, and the bottom faces of the first and the second electrodes being exposed at the bottom surface of the substrate;

an LED die mounted on the top surface of the substrate and respectively electrically connected to the first and the second electrodes, the LED die comprising a positive bonding pad (p-pad) and a negative bonding pad (n-pad); and

an encapsulation layer covered on the top surface of the substrate to encapsulate the LED die therein;

wherein the top face of the first electrode defines a first groove corresponding to the p-pad of the LED die, and at least a portion of the p-pad is inserted into the first groove, an oxidation-resistant metal coating layer being filled between an insertion portion of the p-pad and at least a portion of an inner surface of the first groove wherein the top face of the second electrode defines a second groove corresponding to the n-pad of the LED die, and at least a portion of the n-pad is inserted into the second groove, an oxidation-resistant metal coating layer being filled between an insertion portion of the n-pad and at least a portion of an inner surface of the second groove; and

wherein a portion of the top surface of the substrate located between the first and the second electrodes protrudes from a plane shared by the top faces of the first and the second electrodes by a predetermined distance to reach a bottom side of the LED die.

2. The LED package of claim **1**, wherein the first groove of the first electrode is located adjacent to a junction of the first electrode and the substrate, and the second groove of the second electrode is located adjacent to a junction of the second electrode and the substrate.

3. The LED package of claim **2**, wherein the first groove is adjacent to the second electrode but spaced from the substrate, and the second groove is adjacent to the first electrode but spaced from the substrate.

4. The LED package of claim **1**, wherein a depth of the first groove is smaller than a thickness of the p-pad, and a top portion of the p-pad protrudes beyond the first groove, a depth of the second groove being smaller than a thickness of the n-pad, a top portion of the n-pad protruding beyond the second groove.

5. The LED package of claim **1**, wherein the insertion portion of the p-pad partially contacts with the inner surface of the first groove, and the insertion portion of the n-pad partially contacts with the inner surface of the second groove.

6. The LED package of claim **5**, wherein the oxidation-resistant metal coating layer in the first groove is filled in the gap existing between the insertion portion of p-pad and the inner surface of the first groove, and the oxidation-resistant metal coating layer in the second groove is filled in the gap existing between the insertion portion of n-pad and the inner surface of the second groove.

7. The LED package of claim **1**, wherein the oxidation-resistant metal coating layer filled in the first groove is sandwiched between the insertion portion of the p-pad and the inner surface of the first groove, and the oxidation-resistant metal coating layer filled in the second groove is sandwiched between the insertion portion of the n-pad and an inner surface of the second groove.

8. The LED package of claim **1**, wherein the top faces of the first and the second electrodes are coplanar with the top surface of the substrate.

9. The LED package of claim **8**, wherein the bottom faces of the first and the second electrodes are coplanar with the bottom surface of the substrate.

10. The LED package of claim **1**, wherein a height of the protrusion portion of the top surface of the substrate is not less than a difference between a thickness of the p-pad and a depth of the first groove but smaller than a thickness of the p-pad, and the height of the protrusion portion of the top surface of the substrate is not less than a difference between a thickness of the n-pad and a depth of the second groove but smaller than a thickness of the n-pad.

11. The LED package of claim **10**, further comprising a reflective cup formed on the top surface of the substrate, the reflective cup defining a receiving cavity, and the LED die being received in the receiving cavity and surrounded by the reflective cup.

12. The LED package of claim **11**, wherein the top faces of the first and the second electrodes are trapezoidal and a majority of the top face of each of the first and the second electrodes is exposed at a bottom of the receiving cavity, a side portion of the top face of each of the first and the second electrodes being covered by the reflective cup.

13. The LED package of claim **12**, wherein the substrate is rectangular, and a lateral outer periphery of the reflective cup is aligned with a lateral periphery of the substrate.

14. The LED package of claim **11**, wherein the reflective cup is integrally formed with the substrate as a monolithic piece.

15. The LED package of claim **1**, wherein both the first and second electrodes have a T-shaped transverse cross-section along a thickness direction thereof, respectively.

16. The LED package of claim **15**, wherein both the first and second electrodes include a main body and a branch portion integrally extending downwardly from a central region of a bottom face of the main body.

17. The LED package of claim **1**, wherein the oxidation-resistant metal coating layer is made of gold.

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